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ENTRANCE OF MANKIND INTO SPACE

(15th Anniversary of the First Manned Flight into Space)

G.A. Skuridin, V.I. Sevast'yanov and G.A. Nazarov

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16. Abstract

April 12. 1976 was the 15th anniversary of a remarkable event in the history of mankind — the first flight into space, accomplished by Yu. A. Gagarin. This booklet traces the stages in the development of the idea of manned flight into space, which are inseparably linked with the names of such eminent scientists of our country as K.E. Tsiolkovskiy and S.P. Korolev. It tells of the evolution of the profession of cosmonaut, who has become at present not only spacecraft test pilot but also research scientist solving many scientific and national-economic problems.

The booklet is intended for a wide circle of readers interested in the problems of space flight.

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A N N O T A T I O N

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COSMIC SONG OF MANKIND

. . . with wings outspread,
soar upward,
to the Sun,
our immortal thought!

/ 3*

A. Isaakyan

Yuriy Alekseyevich Gagarin! This name blazes as the Sun, as a stirring call to the High and Beautiful . . . It has left us an immortal memory of a great exploit, unique in the history of mankind and marked by the inspired rejoicing of the entire planet.

Fifteen years ago, from the short command "Ignition!" the rocket engines roared with titantic power, their thunder deafening the steppe surrounding the Baykonur Cosmodrome and the rocket gradually, as if understanding the solemnity of the historical moment, began to gain speed, rising ever higher and higher, carrying the legendary craft Vostok into the sky. And with the counting of the seconds of the flight transmitted through loudspeakers, the beginning of the immortality of the first cosmonaut of Earth was also counted.

Who is he, and from what sources does his immortality arise? We now know much about the life of Yu. A. Gagarin: his entire biography before he first appeared at the Cosmonaut Training Center; we know how he prepared for flight and became the first candidate for this flight, we remember him well when he returned to Earth after the flight and became its hero . . . But how did he arrive at immortality — this subject touches layers deeper than simply the life of an individual man.

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* Numbers in margin indicate pagination in original foreign text.

In each human personality with a capital letter, and this certainly applies to Yu. A. Gagarin, are concentrated and integrated the most daring dreams and desires of certain generations, such as the unbounded moral self-perfection of Man and the unlimited motion of mankind in its development. The first flight into space signifies a transition in the development of mankind to a new, previously unknown state -- the entrance of Man into the infinite spaces of the universe. This then is the greatest historical meaning of the immortal exploit of Yu. A. Gagarin, since his flight reflected the ascent from the age-old idea of space flight to its actual realization. / 4

This historical event was well characterized by the well-known aeronautics specialist K. Ehricke:". . . *The idea of flight to other parts of the Universe is the height of human thought, independent and endowed with rich imagination.* This idea not only imparts dignity to the technical and scientific aspirations of man but also touches the philosophy of his very existence. Like all the basic categories of knowledge, the idea of space life is the fruit of a long evolution. It must have first appeared in a naive form, as if in answer to the grandeur of the star-covered sky. Only later did the idea of space flight become a source of boldly conceived undertakings challenging the apparent limitation of man and his gods. . ."

Man has observed the majestic starry sky for millennia, stricken by its depth and mystery. He strived to reach the sun on the wings of Icarus. Those, who spoke of the infinity of worlds and the knowledge of the universe surrounding man, burned in the fires of the Inquisition. Century after century, the thought of mankind about flight into space grew, matured and found wing. The brilliant artist and engineer Leonardo da Vinci dreamt of a great bird, which began its flight from the back of a gigantic swan, "filling the universe with amazement".

And then -- the dream was accomplished. All the radio stations of the world repeated the same words: "A Soviet man in space . . . Gagarin! . . . Gagarin! . ." The 108 minutes of the space flight astounded the whole world and the rejoicing, which enveloped our planet, was a hymn to Soviet science and technology and to the supreme courage of the man who ascended into space. It seemed that the god-like had happened: "Stop, moment, you are beautiful! . . "

Yu. A. Gagarin said after his flight: ". . . I am happy beyond all measure

that my beloved country was first in the world to accomplish this flight, first in the world to penetrate space . . . Love for our glorious party, for our Soviet Motherland, for our heroic working people inspired me and gave me the strength to accomplish this feat . . . " That was accomplished, of which K. E. Tsiolkovskiy dreamt, when he addressed the Soviet government by letter in 1935: " . . . All my life I have dreamt that my works would move mankind forward at least a little . . . All my works in aviation rocket navigation and interplanetary communications, I give/ 6 to the Bolshevik party and to the Soviet state — the true leaders in the progress of human culture. It is certain that they will successfully complete these works . . . "

And it is wonderful that our nation, which showed all mankind the way to the bright future of Communism under the guidance of the wise Leninist party -- the main source of our heroic accomplishments, could create, in the words of Yu. A. Gagarin, "the most beautiful spacecraft in the world".

One can now speak of the many facts and the events preceding this flight, of the thousands of human destinies, of the technical ideas, the bitter arguments, the faith and doubts, the failures and triumphs. But it should be noted that only the great poets and toilers, the genius of thought and labor, could create the entire grandiose space complex, and not only create but also accomplish the most daring of all manifestations of the human spirit -- the flight of Man into space. And among those who participated in some way in this great exploit, three stand out like a peak from the height of which we now see that grandiose accomplishment of mankind -- Tsiolkovskiy, Korolev, Gagarin. "Each has his own motto in life," said pilot cosmonaut of the USSR G. T. Beregovoy, "Mine always consists of three words: "Tsiolkovskiy, Korolev, Gagarin!". They went forward mastering space. The first voyagers. I think each of the cosmonauts will write with pleasure these names on board the craft he flies. In fact, the flight of each following is a continuation of the path begun by them".

The ideas of K. E. Tsiolkovskiy can be called the most valuable pearls in the brilliant crown of eminent discoveries of our century. In them resounded the cosmic song of mankind -- the striving of Man for the stars. Thanks solely to the flight of Yu. A. Gagarin has mankind finally satisfied to some degree its age-old innate striving for the infinite distances of space, the striving which is the result of the inexhaustable thirst of man for knowledge of the new and unknown,

which has compelled him in the past to abandon the tree and cave, to make his way through inpenetrable forests, to sail over unknown seas, to climb inaccessible heights. / 7

However, in just the last century man was not yet even able to fly above the earth, and the father of the famous American pilots, clergyman Milton Wright, bet on the impossibility of constructing even the most ordinary, simplest aircraft. And not having any other possibilities, not knowing any other means for overcoming the gravity of the earth, man turned to the stars on the wings of his inconceivably rich fantasy.

"I write about that which has never been seen nor experienced nor found out from another, which is not and cannot be in this world, and thus my readers must by no means believe me" -- this refutation begins the first tale of a journey to the moon, which was written by Lucian 18 centuries ago. Much later, even after Galileo had turned his telescope to the sky and Kepler had "observed" in his dreams living creatures on the moon, Cyrano de Bergerac sent an "iron carriage" provided with powder rockets to the moon, and even later Jules Verne described his famous trip from a cannon to the moon. And only at the turn of the twentieth century, when in 1896 the deaf teacher from remote Kaluga (this is the Beethoven of cosmic melodies!) reached the conclusion that the rocket is the only technical means for overcoming the gravity of the earth, only then did the starry dream of mankind finally find tangible reality.

The principle of operation of powder rockets was already widely known by this time: from time immemorial people have loved to set up fireworks displays without attributing any importance to the force with which this primitive rocket climbs upward, scattering colorful fire. But it was K. E. Tsiolkovskiy who first understood that a force is exerted here, which would permit mankind in the future to make its first step to the stars. "Such pitiful phenomena we usually observe on the earth," K. E. Tsiolkovskiy wrote about fireworks in 1911, "This is why they couldn't encourage anyone to dreams and research. Only reason and science could find the transformation of the phenomena to the grandiose, almost incomprehensible feelings". This is the exceptional genius of the great thinker, in seeing ordinary phenomena in a completely new manner and discovering in it the means by which a new direction of human activity would be formulated. / 8

But K. E. Tsiolkovskiy not only foresaw the rocket technology of the cosmic

20th century (in some degree it was also "guessed" by Cyrano de Bergerac and other thinkers), but he also substantiated his foresight by creating an entire science -- the science of flights into space and thereby became the original founder of theoretical astronautics. Later Yu. A. Gagarin said: " . . . Tsiolkovskiy overturned my mind. This was also within the power of Jules Verne and H. G. Wells and the other visionaries. Everything said by the scientist was verified by science and his own experiments."

Now, when flights to the moon have become completely real for us and, in a certain sense, ordinary, when our ear is completely accustomed to the Tsiolkovskiy formula and the Tsiolkovskiy number, when the services of K. E. Tsiolkovskiy in astronautics have been recognized over the entire world, it is difficult even to imagine all the greatness of the exploits of this great thinker, who lived and created, ridiculed and misunderstood in prerevolutionary Russia (even N. Ye. Zhukovskiy gave a negative review to one of his projects!), for the future of mankind. We can only admire that supply of spiritual force, which was put into his research anticipating for mankind a new epoch of great "geographical discoveries", but no longer on the spaciousness of the oceans washing the earth, but in the cosmic depths of the solar system.

Such brilliant models as K. E. Tsiolkovskiy appear before mankind as special moral categories. Each of these people has bequeathed to us wondrous human properties extending our perceptions and feelings. The endless set of facts, which are now completely trivial for us, were at one time a brilliant insight of eminent people standing significantly higher than their contemporaries in this sense. Even that primitive man -- the hunter with his primitive comprehension of the world, in going into the impenetrable depths of the forests and making the first notch in a tree in order to find his way back -- was more brilliant than the other hunters since he was the first to make this notch as a guide post for the future! / 9

Another noted scientist and his friend A. L. Chizhevskiy spoke well of K. E. Tsiolkovskiy: " . . . In his works and creations, Konstantin Eduardovich was a rebel, unsubdued, independent and furiously brave. In order to cast such bold new ideas and truths to the world, it was necessary to have great impudence of thought. The life of K. E. Tsiolkovskiy, his creativity, his dreams, the sources of his spiritual forces -- all this is far more complex, broader and deeper than thought by some of his biographers, judges of his works studying his life from afar from

documents. Many of his biographies are chronologies of the generally known or little known events in the life of the scientist. This is the external side of his activities, and only that. The inner world of Tsiolkovskiy -- the man, the scientist and gentleman -- have remained unrevealed to a significant degree until now . . . "

Complete recognition of the works of K. E. Tsiolkovskiy came only after the Great October Revolution, and in 1919 he was elected as a member of the Socialist Academy, while later the Soviet government decorated him with the highest award -- the Order of the Red Banner of Labor. But A. M. Gor'kiy was completely correct in speaking of K. E. Tsiolkovskiy that "his remarkable intellect will be properly evaluated much later. It is rather difficult for us, his contemporaries, to conceive what he has done for mankind." And this is really so since even now the space age is only just begun, while the dreams of K. E. Tsiolkovskiy were directed immeasurably further. In spite of the fact that K. E. Tsiolkovskiy, in the acknowledgement of the well-known rocket designer W. von Braun, " . . . was the first who understood and developed the idea of applying rockets for space flight . . . and is considered in the world as the original founder of astronautics", the true genius of this great scientist was revealed in his prediction of the distant future of mankind. He wrote in 1911: "Mankind will not always remain on earth, but in the pursuit of light and space will first timidly penetrate beyond the limit of the atmosphere and then conquer all space around the sun". After Man's conquest of space, K. E. Tsiolkovskiy saw the unending development and immortality of humanity: "Man by the strength of his reason will penetrate beyond the limits of the earth, expanding the biological scale of the universe!" / 10

K. Erich spoke very distinctively in this regard in evaluating the first successes in the conquest of space: "We live in one of the sharp moments of history . . . when a transition to a new fundamental stage of development occurs. It is necessary for the birth of a child to cut the umbilical cord connecting the fetus to the womb of the mother. For the birth of a man (as a person), it is necessary to cut the threads connecting him to childhood. If one assumes the existence of a new stage of development of civilization, given birth by the scientific and technical progress, then the dependence of man on the mother planet must be broken (in the sense of its exclusiveness and generality). Mankind, who has mastered space technology in theory and in practice, must not be "condemned to solitary confinement" on one planet . . . This transition to a new stage of

development -- from an existence in the world limited by the biosphere to a new world in open space -- is necessary since the past must not be the only choice of our future."

Actually, in the attempt to reach the stars, there has appeared the instinct long characteristic of man -- to investigate the new and to adapt to new surrounding conditions. Thus, the study of space is the next and highly logical step in the inborn striving of man to expand his ecological niche -- the region of existence of man as a biological form. This foresight by K. E. Tsiolkovskiy of a new state of mankind in its development, the foresight that Earth is only a "cradle" for it is comparable to the feat of Nikolas Copernicus, who first refuted all the delusions about the exclusive position of the earth in the scale of the universe. K. E. Tsiolkovskiy went further -- he was first to throw open the door to the boundless spaces of the universe and to establish the true place of Man in it.

In connection with this, it is interesting to note the following statement of K. E. Tsiolkovskiy: "The rocket for me is only a method, only a technique for penetrating into the depths of space, but it is by no means an end in itself . . . There will be other methods for moving in space -- I accept that . . . The whole point is in the migration from earth and in the settlement of space". A fundamental conclusion follows from the study of K. E. Tsiolkovskiy -- the development of the future of mankind is inseparably linked with the exploration of all spaces / 11
of the universe: "The universe belongs to Man!"

In the great poem "Abul Ala Maari" written by A. Isaakyan in 1909, among the characters, as was accurately noted by Marietta Shaginyan, there is also the Sun (Sun with a capital letter!). The Sun was also such a "character" for K. E. Tsiolkovskiy. When you read his works, it seems at times that he himself is permeated with sunlight. Reason and Sun are inseparable for him: Sun -- the source of life, Reason -- the force capable of controlling the energy of the Sun for prolonging the life of mankind on the earth and the other planets. "In working on reaction devices," wrote K. E. Tsiolkovskiy, "I had peaceful and high goals -- to conquer the universe for the good of mankind, to conquer space and the energy emitted by the Sun . . ."

As no one else, K. E. Tsiolkovskiy understood the tremendous revolutionary

value of knowledge. He wrote: "I want to be Chekhov in science -- to give the serious logical knowledge of the most reliable studies of space in small essays accessible to the unprepared or little-prepared reader". And again: ". . . The basis of all reasonable and good actions and of our future well-being is knowledge."

The study of the sciences opened for him the depth of human thought in the knowledge of nature, and armed him with the greatest weapon for the fight with routine, stagnation and ignorance in all their manifestations. To counterbalance the mystical propaganda of scientific achievements, as was strongly expressed, for example, in the novels and popular books of K. Flammarion, K. E. Tsiolkovskiy in his works created the science of the future, capable of increasing not only the material, but also the spiritual riches of all mankind.

The clearness of purpose in the future is the main thing in the works of K. E. Tsiolkovskiy: "There is no end of life, no end of reason and perfection of mankind. Its progress is eternal. . . " K. E. Tsiolkovskiy considered the reconstruction of the solar system as a new leap in the space activity of man, along with all themes of social transformations which must be produced on earth. He conceived the great work "Socialistic Structure of Mankind", but unfortunately was able to write only individual parts of this grandiose work: "The Riches of / 12
the Universe" (1920), "Monism of the Universe" (1925, 1931), "The Future of the Earth and Mankind" (1928), "The Social Organization of Mankind" (1928). As was noted by the well-known Soviet rocket designer M. K. Tikhonravov, K. E. Tsiolkovskiy was occupied with rockets not for the sake of simple interest, but for the sake of the ideal of the future of human society. Later Yu. A. Gagarin, as if taking the relay baton of generations, said before launch: " . . . I want to dedicate this first space flight to the peoples of Communism -- the society which our Soviet people has already joined and which, I am convinced, all the peoples on earth will join".

K. E. Tsiolkovskiy enunciated a single principle: the world is knowable and must serve the good and happiness of peoples. He said with pride: "I have never worked on anything to improve the methods for waging war". K. E. Tsiolkovskiy did not conceive of the peaceful conquest of space without the world-wide expansion of international collaboration in this area: ". . . Mankind has gained a world-wide ocean granted to him, as if on purpose, to link peoples into a single whole, into a single family".

K. E. Tsiolkovskiy did not have direct students. He laid with his works the future of those who would have to be his successors, who are capable of devoting thie entire spirit, reason, life to the great idea of space exploration with the same passion as he himself. In this sense, he can be compared to the Titan Prometheus, who said to Zeus:

Here I mold people
and in them my image,
a generation similar to me --
in order to be tormented, to weep,
to take pleasure, to be gladdened,
without consideration of you,
as I! . . .

And this generation grew even during the life of K. E. Tsiolkovskiy. All those who came into rocketry during the 1920's and 30's are now its pride -- they sought support for their undertakings most of all from K. E. Tsiolkovskiy. "Before I got to know him," recalls S. P. Korolev, "I was already struck by that immense world which the modest deaf old man was able to put into our heads. Since then it seemed to me that there is no more attractive pursuit than our rocketry . . . " Our celebrated designer sent K. E. Tsiolkovskiy his book "Rocket Flight in the Stratosphere" and received a favorable response on it from the scientist. Another of our eminent designers, the founder of domestic rocket engine design, V. P. Glushko began in youth to correspond with K. E. Tsiolkovskiy. The creator of the first domestic rocket M. K. Tikhonravov visited K. E. Tsiolkovskiy. / 13

A few years passed, and the representative of the new generation Yu. A. Gagarin said: "The prophetic words of Tsiolkovskiy on the conquest of space will always be programmed for us, the cosmonauts, they will always call us forward. . . "

CHIEF DESIGNER OF THE SPACE CENTURY

. . . He scraped the craft
from his cerebral cortex. . .

L. Vysheslavskiy

The twentieth century burst into science and technology like a fresh wind. Radio, aviation, television, automation -- these concepts became commonplace having just scarcely appeared, and in the 20th century (which is more and more called the space century) the age-old dream of mankind was accomplished -- the entrance into space.

Preparation for the assault on the sky was conducted everywhere -- in the USSR, in America, in Germany. And there were launched successfully with a short interval, first the rocket of the American R. Goddard on March 16, 1926, the rocket of the German specialist I. Winkler on February 21, 1931 and the rocket of the Soviet designer M. K. Tikhonravov on August 17, 1933. " . . . Much genuine enthusiasm appeared in the USSR," K.Ehricke admits, "in the business of penetrating space with the help of space rockets in accordance with the prophetic foresight of K. E. Tsiolkovskiy". It was this enthusiasm and also the wide support from the party and government, which stipulated the priority of the Soviet Union to the conquest of space and to the penetration of man into space -- on October 4, / 14
1957 a Soviet rocket took the first artificial earth satellite into orbit, and the great exploit of Yu. A. Gagarin was accomplished April 12, 1961.

The eminent designer of our times S. P. Korolev participated most directly in all these undertakings leading to the triumph of Soviet rocketry. He is correctly called the founder of practical astronautics. In paying tribute to the Soviet scientist, the German pioneer of rocketry H. Oberth said: " . . . I am already old, and at one time lost hope that I would live to the space age. And there in orbit around the earth is a Russian satellite, and after several years in space -- Russian speech . . . Unfortunately, I do not know who designed the powerful rocket and the first craft for the space voyage. Certainly, if my colleague Tsiolkovskiy,

with whom I corresponded, had lived, then we would have exclaimed on meeting the remarkable designer: "Bravo! Bravo! You have accomplished the dream, which nourished our reason for many years and to whose realization we contributed what we could".

Actually, even quite recently the name of S. P. Korolev was little known: The pages of the press of the whole world resounded mysteriously and solemnly -- the chief designer. And thus S. P. Korolev entered the history of astronautics -- as the chief designer of the space century.

S. P. Korolev was multi-faceted in his activity and an entire epoch of remarkable achievements is linked with his name. The eminent organizational capability and talent of the scientist permitted him over a number of years to direct the work of many scientific research and design collectives. "Yes, he was the chief designer," notes B. V. Raushenbakh, corresponding member of the AS USSR, "but there were other chief designers . . . Obviously, the whole point is that he was not simply the chief designer, but the Chief Designer, and thanks to the support and help of high colleagues he occupied the unofficial post of head of the entire scientific and technical direction".

The activity of S. P. Korolev in the post of chief designer was indeed unlimited. He directed the development of the first artificial satellites of the earth, the automatic stations for investigating the Moon (right up to Luna-9, / 15
which accomplished the first soft landing on the surface of the Moon), the first specimens of the spacecraft Zond, Mars and Venera, the spacecraft Vostok, Voskhod, etc. Artificial satellites of the Molniya and Elektron type and many satellites of the Kosmos series were produced under his direction.

However, in all his undertakings, the chief designer never thought of himself as a loner. "Everything that has been done, is being done and will be done in producing rocket carriers, spacecraft, preparation of cosmonauts," S. P. Korolev loved to repeat, "this is a result of the efforts of a considerable group of scientists, designers, engineers, people of genuine talent -- whole collectives". These tremendous collectives headed by eminent scientists produced engines and automatic systems and ground complexes, but, as B. V. Raushenbakh also notes, S. P. Korolev "was a participant of all the developments . . . He set tasks, determined technical characteristics, often . . . made the final decision: yes or

no." All who worked with him note his remarkable feature -- the ability to captivate his associates with the business of conquering space, to enlist the most outstanding scientists, to change the minds of skeptics, to move the business forward methodically with iron persistence. "The characteristic feature of S. P. Korolev," recalls K. P. Feoktistov, participant in the development of the first satellites and later pilot-cosmonaut of the USSR, "is this enormous energy. He was able to infect his associates with this energy."

However, in contrast, for example, to F. A. Tsander with his unbounded energy striving "forward to Mars!", S. P. Korolev clearly presented that much material means and creative forces are required to accomplish the grandiose projects of interplanetary expeditions, and the main one -- it is necessary to strictly limit the selection of problems to be solved. The gigantic energy of S. P. Korolev was always subordinated to his creative self-discipline and brilliant intuition of an engineer in the selection of the next step. He opened inwardly, like a spring, boldly taking chances, but justified chances, and hence necessary. This then is the organic link of the activity of the chief designer S. P. Korolev with the times, his deep understanding of the spirit of the times. Guided by the tremendous / 16
legacy of K. P. Tsiolkovskiy, he used it as required by the time itself. When in the 1930's S. P. Korolev became one of the first in the country to gather around him people who were enthusiastic about rocketry, he already realized well at the same time how much effort and time would be required to accomplish space flight. "I came into rocketry with the hope for flight into space ...," S. P. Korolev said later on, "but there were no real possibilities for this for a long time; one could only dream about the orbital velocity!"

The path ahead was thorny and, perhaps, the most difficult in the entire history of science and technology. In his book "Rocket Flight in the Stratosphere", S. P. Korolev wrote in 1934: . . . "How is the problem of manned flight to be solved? Without question, if we mean flights above 30 km, this will not be managed without rockets". And later: "Without a reliable rocket motor, well thought out and developed in all its details and parts and tested in practice, it is impossible to speak of any supernatural achievements. The rocket motor is the center of attention!" Much later he defined the rocket engine as the "power heart of the rocket". Thus -- rocket engines!

In the Rocket Engine Study Group (RESG), directed by him from 1932, he first

turned attention to the production of engines similar to those developed by F. A. Tsander, M. K. Tikhonravov and other designers. At the same time, S. P. Korolev showed intent interest in the development of liquid-propellent reaction engines accomplished under the direction of V. P. Glushko in the Leningrad Gas Dynamics Laboratory (GDL). Appearing at the first All-Union Conference on the application of rocket devices for stratosphere research, S. P. Korolev notes, in particular, in his report: ". . . Powerful liquid-propellent rocket engines occupy the main place. The accomplishment of manned flight on rocket devices depends directly on achievements in this area. . . "

The launch of the first domestic hybrid-fuel rocket developed at the RESG in the project of M. K. Tikhonravov with the direct participation of S. P. Korolev was accomplished August 17, 1933 at the Nakhabino test ground near Moscow. In his note in the news bills posted on this occasion, S. P. Korolev wrote: "The day of August 17 is without question a significant day... and beginning from this moment, Soviet rockets will fly above the Union of republics. . . Soviet rockets will conquer space!" Even earlier, in the article in "Vechernaya Moskva", he stated the truly prophetic words: "The rocket is the real lightning of the approaching technical victories of Communism!" / 17

However, the creation of the rockets and rocket engines of S. P. Korolev at the initial stage of realization of his space program was never considered out of touch with the main program -- the flight of man, even if only in the stratosphere, but with the use of a rocket device. He began in 1932 to develop such a device -- the rocket glider. As Academician V. P. Glushko noted later, the rocket glider became the precursor of jet aviation, the first practical answer to the thought of K. E. Tsiolkovskiy that after the era of propeller aircraft would begin the era of jet aircraft.

The flight of the rocket glider RP-318-1 piloted by V. P. Fedorov was successfully accomplished February 28, 1940. / 18

Beginning in 1934, the world's first Jet Research Institute (JRI) under the direction of S. P. Korolev developed a whole series of winged missiles. The first flight of the winged missile 216 with a gyroscopic autopilot was accomplished May 9, 1936, and the flight of the improved winged missile 212 on January 29, 1939. It is very possible that the creation of the winged missiles and the winged device --

the rocket glider -- of S. P. Korolev was linked at the same time to the future of astronautics. In the article "The Path to Rocket Navigation," he wrote: "From experimental rockets and cargo rockets to rocket craft and rocket gliders -- this is our path". It is very probable that this idea could have originated under the influence of the theoretical works of F. A. Tsander (whom S. P. Korolev undoubtedly knew), who proposed horizontal landing of future spacecraft. Thus, the rocket gliders developed at the time by S. P. Korolev were, one can say, the prototype of those space systems with horizontal landing, which are now being developed in the USA and (what is most notable) are based on the winged design.

In the prewar years, JPI and other organizations developed a broad program of research, which was to be concluded with the creation of numerous experimental rockets with liquid-propellent, solid-fuel, ramjet, hybrid and combination rocket engines. The famous Katyusha mortars were produced in the same years. Much work was carried out in the war years in producing liquid-propellent rocket boosters for production combat aircraft (under the direction of V. P. Glushko). A multi-stage rocket for investigating cosmic rays at high altitude was developed in 1944.

After the war, S. P. Korolev returned with even greater enthusiasm to his design activity. Deeply understanding the value of the grandiose socialistic transformations in our country, the continuously growing technical power, the prospects in the development of science and guided by the support of the Soviet government, he proposed a bold program of scientific, technical and practical works in / 19
in rocketry.

In February 1947, S. P. Korolev was designated chief designer of the Experimental Design Bureau (EDB). This designation was in recognition of his service as one of the most outstanding specialists in rocketry in our country.

During this time, an experimental model of a ballistic guided missile was produced under the direction of S. P. Korolev, and the launch of the first Soviet medium-range ballistic missile R-1 in October 1948 was a result of this work. A series of geophysical high-altitude rockets was produced on the basis of this and subsequent missiles and a comprehensive study of the space around the earth became possible. Launching was begun in 1949 of powerful geophysical rockets, which were also used after 1951 for biological experiments.

The development of an intercontinental ballistic missile was begun under the

direction of S. P. Korolev in the Soviet Union in the beginning of the 1950's. Its production was one of the largest-scale technical developments in forces and means ever accomplished in the USSR and was linked with the development of almost all branches of science and technology.

The launch of the first intercontinental ballistic missile in the world was accomplished August 21, 1957 from the Baykonur cosmodrome, which was specially constructed for launching large rocket carriers. TASS reported: ". . . The tests of the missile were carried out successfully; they completely verified the validity of the calculations and the chose design. The flight of the rocket went to a very high, previously unattained altitude. After going a tremendous distance in a short time, the rocket fell into the specified area."

S. P. Korolev understood well that the production of intercontinental missiles opened tremendous promise for space flight. With the help of this two-stage rocket with engines developed by the collective headed by V. P. Glushko, the first artificial earth satellites were later developed. Speaking on September 17, 1957 at the ceremonial meeting in the House of the Union, which was devoted to the centennial of the birth of K. E. Tsiolkovskiy, S. P. Korolev declared with complete justification: ". . . A successful test of an extralong-range intercontinental multi-stage ballistic missile has been carried out in the Soviet Union. . . The / 20
first test launches of artificial earth satellites will be carried out for scientific purposes in the USSR and the USA in the immediate future."

However, while the launch of the American artificial earth satellite was widely publicized in the foreign press, few knew about the possibility in the immediate future of a satellite launch in the USSR and, moreover, almost no one supposed that literally several days at the most after this celebration in the Soviet Union there would be put into orbit the first artificial earth satellite in the world, thereby ushering in the space age.

Now, when one recalls the dullness of preparing this great assault on space, it is even difficult to imagine how unusual everything was. It was necessary to take into account each kilogram of useful load, its power, the volume of data to be transmitted. Ideas grew spontaneously since the first tests were going to be carried out under space conditions -- the unknown laboratory of Nature.

Prophecies about the closeness of coming space events were heard more and more persistently in the world press from the end of the 1940's. In July 1948 at the annual section meeting of the Artillery Sciences Academy, the creator of the first domestic rocket M. K. Tikhonravov gave in his report the theoretical basis for the possibility of achieving the orbital velocity with the help of multi-stage rockets and, consequently, the launch in the near future of an artificial earth satellite. A small group of specialists was formed in 1950, headed by M. K. Tikhonravov, who was completely occupied with theoretical investigations of the possibility of constructing artificial earth satellites, including manned satellites. / 21

It should be admitted that this work did not receive the required support for some time, and only thanks to the personal interest and insight of S. P. Korolev did it receive proper appreciation. As one of the co-workers of this group, a participant in producing the famous Katyusha, V. N. Galkovskiy recalls: " . . . Work on the theory of the flight of an artificial earth satellite was performed by the group during 1950 - 1955. . . This work enjoyed the assistance of S. P. Korolev and the organization under his direction".

At the end of 1955, after becoming acquainted with the results obtained by this group, S. P. Korolev decided to enlist these scientists directly in the work of his Experimental Design Bureau. He wrote: " . . . Comrade Tikhonravov is one of the oldest rocketeers in the Soviet Union, who is continuing the development of the ideas of K. E. Tsiolkovskiy, and his participation in the work of our organization in producing a satellite will help this pursuit in a decisive manner".

The group of N. K. Tikhonravov transferred in 1956 to the EDB directed by chief designer S. P. Korolev. They were also joined by the future cosmonaut and, at that time, a recent graduate of the Bauman Moscow Higher Technical School, K. P. Feoktistov.

By this time, the interest of scientists of the whole world in the possibility of launching an artificial satellite had significantly intensified in connection with the forthcoming International Geophysical Year (IGY) in 1957 - 1958. The decision was made in the USA in the summer of 1954 to create a national program linked with the launching of a satellite, which would finally be formulated in the Vanguard project; this project received the support of the government of the USA / 22

from 1955. Development was also continued for the American satellite, for the launching of which it was proposed to use the powerful ballistic missile Jupiter-C produced with the participation of W. von Braun.

It became clear by the second half of 1955 that only two countries, the USSR and the USA, who had the potentialities for producing powerful ballistic missiles, could actually accomplish the launch of the first artificial Earth satellite.

The regular congress of the International Astronautical Federation (IAF), in which Soviet scientists participated for the first time, was open August 3, 1955 at the Polytechnic Institute in Copenhagen. The Soviet scientists represented the commission for the Academy of Sciences of the USSR for research and use of space for peaceful purposes, which was formed under the chairmanship of Academician L. I. Sedov (the Soviet Union became a member of the IAF in 1956). At the present conference at the Soviet Mission in Copenhagen, the congress participant Academician L. I. Sedov recounted the work of Soviet scientists in astronautics to the Danish and foreign journalists. In particular, he announced that: "much attention has been paid recently in the USSR on research problems related to accomplishing interplanetary communications, in the first place, to the problem of producing an artificial Earth satellite . . . The realization of the Soviet project can be expected in the comparatively near future". This announcement of L. I. Sedov made the strongest impression on the journalists and specialists present and was published in many newspapers of the world.

On August 30, 1955, the leading specialists in rocketry and also other scientists assembled in the office of the chief scientific secretary of the Presidium of the AS USSR Academician A. V. Topchiyev. S. P. Korolev gave a brief account to those assembled on the course of work in testing a new powerful rocket capable of taking an artificial object of significant weight into orbit around the Earth. After consideration and discussion, the participants of the meeting decided to select a group of scientists headed by M. V. Keldysh (who later became known as the chief theoretician), which would develop a program of scientific experiments / 23
for the first artificial satellites. Recognizing the entire significance of the historic undertaking, the Soviet government supported the initiative of the Academy of Sciences of the USSR and the other departments, and at the end of January 1956 decided to produce a Soviet artificial Earth satellite during 1957 - 1958. A special commission with the broadest powers was created with the Academy of Sci-

ences of the USSR with M. V. Keldysh as chairman and S. P. Korolev and M. K. Tikhonravov as vice chairman.

The talent of S. P. Korolev as an eminent scientist and organizer was revealed in full force at this time. Numerous meetings on technical problems related to the development of the first satellites were carried out under the guidance of the chief designer. Much which had already been prepared in drawings often had to be changed as a result of these meetings and also meetings on the scientific program of the satellites carried out under the guidance of M. V. Keldysh. As into the seething current of a tremendous river, numerous tributaries -- various research institutes and design bureaus developing many assemblies for the satellite -- flowed into the work or the specialists directly occupied with the satellite project. S. P. Korolev was occupied with virtually all the problems including the rocket and the engine and the launch devices and the command points and many, many others.

At the same time, S. P. Korolev proposed, besides the developed heavy satellite with a varied program of scientific experiments, a project for the simplest satellite of spherical form with a radio transmitter and the necessary instrumentation on board. It was this satellite which later was the first to be put into orbit around the Earth.

Work on the satellites was reaching its conclusion by the middle of 1957. At this time, the newspaper Pravda (July 1, 1957) published an article by the president of the Academy of Sciences of the USSR A. M. Nesmeyanov "Problem of Producing an Artificial Earth Satellite". It said, in particular: " . . . As a result of the many years of work of Soviet scientists and engineers, there have now been / 24
created the rockets and all the necessary instrumentation and apparatus with which the problem of an artificial Earth satellite for scientific research purposes can be solved . . . The creation and launch of a Soviet artificial Earth satellite for scientific purposes in the International Geophysical Year will play an exceptional role in joining the efforts of scientists of various countries to taming the forces of nature. . . "

The Soviet Union did not conceal its preparation for the launching of a satellite; however, almost no one suspected that this launch would be accomplished in this very year -- the year of the 40th anniversay of the Soviet state. On

October 4, 1957, the first artificial Earth satellite in the history of civilization was put into orbit from the Baykonur cosmodrome. "Today has been accomplished," S.P. Korolev said on this day, what the best sons of mankind have dreamt and among them our remarkable scientist Konstantin Eduardovich Tsiolkovskiy. He brilliantly predicted that mankind would not remain on Earth forever. The satellite is the first verification of his prophecy. The assault on space has begun. We can be proud that it began in our country."

Rejoicing enveloped the entire planet. Words of admiration and gratitude were brought from all corners of the Earth. In noting the priority of Soviet space technology, J. Kennedy wrote: "We have become witnesses to the fact that the beginning of achievements in space was set by the Soviet Union thanks to their powerful rocket engines. This ensured the leading role to the Soviet Union."

Soon after, a second Soviet satellite with the famous dog Layka onboard was launched into orbit around the Earth and only three months after this, the first American satellite Explorer-1 was put into orbit with the help of the Jupiter-C rocket (after a series of unsuccessful attempts, the widely publicized Vanguard was launched only much later). Soviet scientists and designers congratulated their transatlantic colleagues for these achievements. The assault on space continued.

In the 3 1/2 years after the first break-through into space, a large number of satellites was launched, and also lunar satellites and artificial "planets". / 25
A Soviet automatic interplanetary station was sent to Venus. But everyone awaited the great event -- when man would be sent into space. As early as the historic meeting devoted to the centennial of K. E. Tsiolkovskiy, which preceded the launch of the first satellite, S. P. Korolev said: "Soviet scientists are working on many new problems of rocketry, for example . . . on the problem of manned rocket flight . . . "

The dream of the flight of man into space had captured S. P. Korolev from his very first steps in his career as rocket designer. He even longed to accomplish such a flight himself and somehow recognized: "I dreamt before of flying on aircraft of my own design, but after meeting Tsiolkovskiy, I decided to construct rockets only and to fly on them. This became the meaning of my entire life. . . I was always drawn to flying and to fly myself. . . "

This same dream undoubtedly haunted him when he flew his own glider, which was the basis for his rocket glider. However, the years passed and it seemed that the flight of man into space would be postponed for an incrediby long time. In a letter to Ya. I. Perel'man, for example, S. P. Korolev wrote: ". . . There will be the time when the first earth vessel will first leave the Earth. Let us live until then. . . "

But alreay after 20 years, when flight into space had become a tangible reality, S. P. Korolev devoted all his efforts to bringing this thrilling moment in the history of all mankind closer. Even in the 1930's, in considering the forthcoming flight of man in the rocket glider, he said in one of his speeches: "What will the basic features of the flight of man on the winged missile involve? This question can be briefly answered thus. Firstly, the flight will be high, consequently, the pilot must be provided with everything necessary for working at high altitude (a pressure suit, a pressurized cabin, the appropriate vital stores, etc.). Secondly, lift-off, take-off and ascent and also the curved portion of the flight will be characterized by significant changes in velocity, because of which the human organism will be subjected to the effect of the booster for the course of the known time interval . . . "

Many years passed after this address, but the basic questions raised by S. P. Korolev were also urgent in preparing for the historic flight of Vostok. However, / 26
serious new technical problems also arose, mainly related to the production of a new, more powerful rocket carrier. To develop its third stage, the chief designer enlisted the collective of designers headed by S. A. Kosberg, who had successfully proven himself before this by the production of a series of models of jet aircraft engines.

S. P. Korolev with his design collective moved steadily toward the projected goal, and as a result, he and his helpers successfully produced a rocket carrier, which was truly a "machine of the century". It had such characteristics and such design perfection which was unsurpassed in the history of world rocket design for almost 10 years. The creation of such a rocket ensured not only the successful launches of the first and succeeding Vostok spacecraft, but also the performance of the entire general space program carried out by the Soviet Union during these years.

Having a powerful rocket carrier in his arsenal, the chief designer began the direct development of his apparatus for the flight of man -- the Vostok spacecraft. To develop the retrofire engines of spacecraft, S. P. Korolev enlisted yet another design collective headed by A. M. Isayev, the same one who at the dawn of jet aviation had produced together with A. Ya. Bereznyakiy the first aircraft in the Soviet Union with the BI-1 rocket engine (named from the first letters of the names of designers).

While the problem of the capabilities of putting a spacecraft into orbit and transferring it to a descent trajectory did not represent special complication at that time, the descent itself into the atmosphere was a complex problem. "The choice of the method for descent into the atmosphere was somewhat more complex," recalls K. P. Feoktistov, "One could choose either the method with the use of aerodynamic lift or the ballistic descent method with the use of drag only. The ballistic braking method was taken for the first satellite spacecraft. . . "

The first flights of experimental satellite spacecraft were begun in 1960. From May 1960 to March 1961, five launches of these spacecraft were made, four of which had experimental animals onboard to accomplish medical and biological research both during flight as well as after their return to Earth. / 27

The thorough preliminary work on the Vostok satellite spacecraft ensured the complete success of the first flight of man in space, which took place on April 12, 1961, when Yu. A. Gagarin, the first cosmonaut of Earth, accomplished his immortal flight around our native planet.

"Of course, I am not a specialist on space problems," said the well-known Danish physicist N. Bohr during these days, "but as a scientist, as a thinking human, I am glad to hail your researchers. The route of the Vostok spacecraft beyond the clouds is a new chapter in the golden book where the noble enter the greatest daring achievements of our century."

Another well-known physicist and public figure F. Joliot-Curie wrote on the occasion of the flight of Gagarin: "This great victory of man is a turning point in the history of civilization. Man will no longer be chained to his planet. . ."

The way into space paved by Yu. A. Gagarin soon led to many other outstanding

achievements thanks to the subsequent space flights of Soviet cosmonauts. Among these were the first group flights of Soviet cosmonauts, the flight of the first woman cosmonaut V. V. Nikolayeva-Tereshkova, the first space crew onboard the Voskhod and, finally, the first "walk in space" performed by A. A. Leonov.

And all these successes were also linked with the name of S. P. Korolev, who was attracted by everything new and new peaks of creative search. The chief designer attached tremendous importance, in particular, to the creation of a manned orbital station and space transport systems. "That which seemed unrealizable for centuries," wrote S. P. Korolev, "which only yesterday was only an age-old dream, has become a real problem today, and will be achieved tomorrow." And all the activity of chief designer of the space century was always directed to the future, and thus the immortal name of S. P. Korolev is linked with all the new achievements of the space age.

DAWN OF THF SPACE AGE / 28

The years, the human constellation,
ever farther, farther into space. . .
V. Khlebnikov

It is strange and remarkable to the highest degree that the birth of Yu. A. Gagarin coincided (1934) with certain significant events in the formation of rocketry in our country: with the firing of the first domestic rockets and with the creation in the Soviet Union of the first Jet Research Institute in the world. At this same time, there was completely revealed the remarkable talent of S. P. Korolev, who during these years took on, like the baton of the generations, the idea about space flight of K. E. Tsiolkovskiy, who passed away in 1935. And inconsistently personifying this idea, the chief designer created with his collective the first artificial earth satellite in the history of mankind.

The launches of the first two artificial satellites of the earth in 1957 were again decisive events in the fate of Yu. A. Gagarin, who graduated in this year from military aviation school; he realized completely at this time the grandeur of the coming events and his desire to participate in them. ". . . On

November 3, 1957 there was already one Soviet artificial Earth satellite flying in the sky," recalls Yu. A. Gagarin. "After one -- there was two! It was many times larger and heavier; the dog Layka was on board in the pressurized cabin. . . In reading those newspapers describing the flight of the second artificial satellite of the earth, I wondered: 'Now that a living creature was already in space, why can't a man fly there?' And I thought for the first time: 'Why can't I become this man?. . .'"

Shortly after, he wrote a report to the commander of his unit: "In connection with the expanding space research, which is being carried out in the Soviet Union, people may be needed for the first flights into space. Please consider my eagerness . . . "

At this time, thousands of Soviet citizens -- patriots of their country -- of all ages and professions expressed the desire to accomplish the flight into space, and in noting this mass character of people desiring to accomplish the feat, L. I. Brezhnev in his speech at the XVII Congress of the All-Union Leninist Young Communist League said: ". . . The destinies of Korolev and Gagarin are the most striking example of what wide scope and potentialities are open by socialism to the working man, to our young people". / 29

However, in spite of the universal enthusiasm and the tremendous number of those who wish, Soviet scientists had a very complex problem of a scientifically based selection of the first cosmonauts -- no one knew what awaited man in space. Many scientists in general doubted the possibility of manned flights in the immediate future; they doubted that man was capable of enduring the overload at the launch of the spacecraft; they feared the effects of radiation and weightlessness, while some foreign investigators thought that the psychology of man would not be able to endure the long isolation in the confined space of a spacecraft. Thus, both in the USSR and in the USA, specialists encountered significant difficulties in the selection and preparation of the first cosmonauts.

Firstly, it was decided to make the selection of the first cosmonauts only from jet pilots. "The intelligent pilot is the best friend of the designer," said S. P. Korolev on his first meeting with the future cosmonauts. "The designer entrusts his offspring first to him, the test pilot. . . " Actually, such professional qualities as quickness of reaction, good capability of enduring noise,

vibrations, accelerations and combinations of these factors, experience in carrying out observations and recording them, will power and, of course, perfect health spoke in favor of the test pilot. At the same time, since the Vostok resembled a complex cybernetic device rather than an aircraft in the complexity of its systems and in the characteristics of the control processes, the qualification of test pilot alone was not required for our first cosmonauts; simply the experience in flying jet aircraft was sufficient.

Secondly, it was decided to limit the selection to rather young candidates in order to have the promise of using them again later.

Guided by these criteria (which were not the principal ones in later selections), selection commissions began their work in different parts of the country. They interviewed pilots, who had expressed the desire to become cosmonauts, and the best / 30 prepared of them were then examined even more thoroughly.

On October 3, 1959 in the aviation hospital in which the final selection was carried out, Yu. A. Gagarin first became acquainted with P. R. Popovich, V. M. Komarov, P. I. Belyayev, A. A. Leonov, A. G. Nikolayev, G. S. Titov, V. F. Bykovskiy and other cosmonaut candidates.

With the first detachment of pilot cosmonauts (the "Gagarin set") was also born Star City, which then consisted of living quarters, office, dining hall and class rooms located in a two-story building. The veteran of Soviet aviation N. P. Kamanin participated most directly in the creation of Star City, in the formation of the first detachment of cosmonauts and in their preparation for flight. He, along with other participants, became the first holder of the highest decoration of our country -- the star of Hero of the Soviet Union. Thus, under the direction of one of the first Heroes of Soviet Union, the preparation of future heroes of space was conducted.

After the formation of the group of pilot cosmonauts, their first studies and training began, entering into a wide program of preparation of man for flight in a spacecraft. The program of instruction provided for the study of the fundamentals of rocketry and space technology, the design of the Vostok spacecraft, special problems of astronomy, geophysics, fundamentals of space medicine. The special training program included dynamic exercises on the rotating wheel,

on the rocking table, running on a treadmill, riding on a bicycle, tests in the centrifuge, on a vibration stand, in a pressure chamber, in a temperature chamber and anechoic chamber (a specially equipped sound-insulated chamber), and also flights in aircraft under weightless conditions and parachute jumps. Doctors and psychologists were commissioned to conduct the entire basic preparation of the cosmonauts. A large circle of physiological investigations and special psychophysiological techniques permitted revealing persons having the better indicators in accuracy, clarity in performing tasks, having better emotional stability. In the journal of one of the doctors appeared the following entry about the preparation of the future cosmonauts: ". . . Yu. A. Gagarin and G. S. Titov stood out sharply immediately. . . Yuriy and Ge man operate more precisely than any computer". / 31

A group of cosmonauts prepared directly for the first flight into space was selected as a result of the performed instructional training operation. This was the time of the most crucial stage of training -- work in a pressure suit, in a working model of the spacecraft and on a specially made trainer, and also special preparation including the study of flight assignments, maps of the landing region, flying instructions, radio communications, etc.

A press conference devoted to some results of investigations carried out on Soviet satellites was held on March 28, 1961 in the conference hall of the Academy of Sciences of the USSR. All of the cosmonauts were present but, although they sat in the very first rows, there were few who paid attention to them.

The press conference was opened by the vice president of the Academy of Sciences of the USSR, A. V. Topchiyev, who said in particular: "The flight of man into space is approaching. . . Soviet specialists have carried out numerous tests of the pressurized cabin and equipment for maintaining normal temperature, air composition, atmospheric pressure. . . All of these tests have given positive results".

However, even when practically all was ready for the first launch of a spacecraft with man on board, opinions were still being expressed about weightlessness as a factor fatal for man (although all the selected cosmonauts had easily endured the state of short-term weightlessness produced in aircraft), about the possible depressurization of the cabin, about the pressure suit, which might not

withstand the impact of meteoritic particles, and about many other dangers lying in wait for the cosmonauts. It was proposed to perform a suborbital flight first -- a flight along a ballistic trajectory to an altitude of 150 - 200 km.

In fierce discussions at the State Commission with the spokesmen of this "super-cautious opinion", S. P. Korolev argued that such an experiment with the suborbital flight of a cosmonaut would contribute almost nothing to science or to technology. M. V. Keldysh supported the chief designer at one of these "skirmishes" / 32 at the State Commission. In particular, he said: ". . . The information about the factors of space effects, which we have available, is actually still insufficient and contradictory. ... The first flight will undoubtedly entail known and completely valid risk. But is this not the property of true science? Could we bind the legs of a child already beginning to walk and force him to sit? . . . Someone said to us: 'Manage the problems on earth and then climb into space'. Absurd. Completely absurd. The discoveries in space, I am sure of this, will hasten the solution of many scientific, technical and other problems on Earth, will make the life of man happier. . . "

But the time for preparing the cosmonauts was approaching the end -- the time for the government examinations was beginning. Everyone understood that the first space flight could be accomplished only by the man, who realized the enormous responsibility of the task given him and would voluntarily agree to give all his effort and knowledge and, perhaps, even his life to accomplish this feat. "We do not hide the complexities and even the dangers of the forthcoming flights from the cosmonauts," said S. P. Korolev. "Their agreement indicates not only an understanding of the problems which they will have to solve but also the courage, the desire to make their contribution to science. For this, we, the scientists, highly value and respect them".

On April 6, 1961 the members of the State Commission signed the flight assignment for the first candidates for flight on the Vostok craft. In the time remaining before launch, the commission would have to finally select the commander and his backup for the first spacecraft in the world. ". . . Gagarin had so many pluses in knowledge and in strength and in character," recalls cosmonaut of the "Gagarin set", A. G. Nikolayev, "that we, his friends, even before the decision of the State Commission became known, knew as one man: "Yuriy will surely fly . . . "

Many members of the State Commission also had no doubt about this. "To accomplish the first flight," recalls M. V. Keldysh, "it was necessary to select a man having not only the necessary knowledge and capabilities, but endowed with exceptional courage, tenacity, selflessness, steadiness. Yuriy Gagarin was such a man." / 33

A meeting of the State Commission was held on the evening of April 10, 1961, at which, after the report of S. P. Korolev about the readiness of the rocket carrier and the Vostok spacecraft for launch, N. P. Kamanin spoke. "It is difficult to single out the best," he said, "but, in our opinion, we can assert that Yuriy Alekseyevich Gagarin is first".

And there at Baykonur, the dawn of April 12, 1961 arrived, to be forever entered in the history of mankind as the dawn of the space age. At 9:07 Moscow time, the first manned Vostok spacecraft with the first cosmonaut of Earth on board was launched into space. The unforgettable "Go!" of Gagarin was heard, and later the unbounded joy of the exclamation of the first man to view the Earth from space: "How beautiful!" / 34

During the entire portion of orbital injection, Yu. A. Gagarin maintained continuous radiotelephone communications with the flight guidance center on the Earth. The cosmonaut felt well on this portion. He clearly fixed the change in overloads and the times of sparation of the rocket carrier stages.

After entry of the craft into orbit, in accordance with the assignment and flight program, he observed the operation of the equipment, maintained telephone and telegraph radio communications with the Earth, made observations from the porthole and in the optical navigator, reported to Earth and recorded the data of the observations onto charts and on a tape recorder, took food and water.

The state of weightlessness, of the greatest concern for the physicians, began at once after entry into orbit. And although this state was unusual at first for Yu. A. Gagarin, the cosmonaut soon felt completely comfortable with it. Yu. A. Gagarin felt well during the entire flight in weightlessness and his capability was completely maintained.

Thus, the first flight into space in the history of mankind, accomplished by

Yu. A. Gagarin, permitted reaching the conclusion (of tremendous scientific value!) about the practical possibility of manned flight in space. K. E. Tsiolkovskiy was correct when he predicted that the absence of garvity for an arbitrarily long time would be endured by man without bad aftereffects. S. P. Korolev was correct in advocating the single-orbit flight program at the State Commission. And finally, Yu. A. Gagarin himself was correct when he also believed in complete success following after K. E. Tsiolkovskiy and S. P. Korolev and thus said several days before launch: ". . . One must fly only with unbounded faith in success."

At 10:25, in accordance with the specified flight plan, the retro-rocket switched on and operated reliably and at 10:35 the Vostok entered the dense layers of the atmosphere. At 10:55 the first cosmonaut of the planet landed safely 30 km from the city of Engels in the Saratovsk region.

The flight of Yu. A. Gagarin on the Vostok spacecraft coincided with the meeting in Florence of the Council of COSPAR (Committee on Space Research with the International Council of Scientific Unions), at which the Soviet delegation headed by A. A. Blagonravov was present. In paying tribute to the exploit of Yu. A. Gagarin, the head of the American delegation, R. Porter declared: "Scientists of the United States hail the outstanding scientific and technical achievements of the Soviet Union and send their congratulations to the first astronaut, Yuriy Gagarin. I am sure that the first step of man into space will inspire all the peoples of the world and serve as an incentive for further successes in the development of science and technology." / 35

"Soviet friends, your Yuriy is not just yours," wrote Rockwell Kent during this time, "he belongs to all mankind. And the gate to space, which he has opened, has been thrown open for all of us. But peace is needed for this. Peace to investigate the universe which our Soviet brothers have opened for us. Peace to bring home the riches of space and to distribute them to all. . . Let mankind honor the day of the flight of Yuriy as the day of universal peace. . . "

After Yu. A. Gagarin, who, in the apt expression of S. P. Korolev, "discovered space navigation", other Soviet cosmonauts were lifted into space, and each following flight was a new achievement solving new, more complex technical problems, a new record in the weight of the craft, altitude, duration, complexity of the flight.

The second flight was for a day. And again the doubts -- man is incapable of enduring the state of weightlessness for even an hour and suppose the vestibular organ should fail. . . In giving an interview before the launch of Vostok-2 with G. S. Titov, M. V. Keldysh declared openly: "The long flight of a cosmonaut will give us a more complete and that means a more precise answer to the question as to what effect weightlessness and other space factors have on the human organism over the course of days. . . It is important above all to establish whether weightlessness has a harmful effect on the capability of the pilot."

However, this and subsequent flights of Soviet and American cosmonauts with ever increasing duration of the effect of space factors (the duration of continuous stay in space has now reached 84 days) proved the inaccuracy of the many predictions made in the 1950's by overly cautious and skeptical medical specialists, / 36 who persistently insisted that a stay in space would be deadly for man, while his normal functioning there was all the more out of the question. It is true that weightlessness, which had been most feared in space, suddenly and unexpectedly caused an impact on Earth. And the first to endure this impact -- readaptation -- were the Soviet cosmonauts, A. G. Nikolayev and V. I. Sevast'yanov, who were first in the world to spend 18 days in space. But this was much later.

The first flights of man into space look very modest by present standards. However, each new voyage into space gave a push to the next, contributed its part to the technology of manned space flights and raised new goals for mankind. A new achievement of Soviet astronautics was the first group flight of the spacecraft Vostok-3 and Vostok-4, piloted by A. G. Nikolayev and P. R. Popovich respectively.

Among the most characteristic virtues of A. G. Nikolayev, in the opinion of S. P. Korolev, two can be picked out: "tranquility and reliability". It was A. G. Nikolayev who was entrusted with performing one of the most important and crucial experiments for this time -- to release his straps and to move freely about the cabin of the spacecraft. The predictions of the physicians were again in this case far from optimistic. Some specialists feared that if the cosmonaut, in leaving his seat, was suspended by the currents in the cabin, then perhaps he would not be able to return to his working position and then would arise the situation full of surprises at landing.

However, S. P. Korolev boldly took the chance, although he completely under-

stood the dangers which awaited the cosmonaut. "I am a great optimist," said S. P. Korolev, "and I believe that greatly extended manned space flights are not very far off. But nonetheless, weightlessness and its effect on the human organism are far from being understood. I think there is little optimism now."

The successful completion by A. G. Nikolayev and later by P. R. Popovich of the planned experiment in free motion about the craft cabin justified the risk assumed by S. P. Korolev and his colleagues. Moreover, the successful accomplishment of the group flight brought closer the possibility of accomplishing docking of spacecraft, to which S.P. Korolev had attached very serious importance. "This is a great and very important matter," he said after the return of the cosmonauts to the earth, "the problem of rendezvous and connection or, as we say, docking of the spacecraft. It has been placed on the agenda for space navigation." / 37

Yu. A. Gagarin participated most directly in the preparation of these and subsequent space flights; he was at test launches, he helped his friends in training, he communicated with the cosmonauts during their flights. The outstanding capabilities of Yu. A. Gagarin were properly appreciated by his comrades and by those who were directly at the head of cosmonaut preparation. Immediately after his own flight, he became head of the cosmonaut detachment, then commander of this detachment and finally assistant chief of the Center for Cosmonaut Preparation. "In Gagarin," noted S. P. Korolev, "was happily combined an analytic mind and exceptional diligence. I think if he receives reliable education, we will hear his name among the most famous names of our scientists". It must be said that Yu. A. Gagarin himself and many other cosmonauts understood the necessity of further increasing their knowledge, and soon after a large group of cosmonauts entered the N. Ye. Zhukovskiy Air Force Engineering Academy.

Yu. A. Gagarin saw in the flights of man into space not only the greatest scientific and technical achievement and accomplishment of the centuries-old dream of mankind, he saw further. "It is impossible to stop flights into space," he said. "This is not the pursuit of just one person or even a group of persons. This is a historical process to which mankind must naturally come in his development".

New people arrived to work at the Center. In talking to the next reinforcement of the detachment, Yu. A. Gagarin advised the future cosmonauts: "Develop

your resourcefulness and analytic thinking, develop your reactions. . ." At this time, women also appeared in the detachment of cosmonauts. Their program of physical preparation was somewhat lighter as compared to the preparation of the men; however, the theoretical studies were carried out the same for all. Everyone in the detachment of pilot cosmonauts, and especially Yu. A. Gagarin, helped the women both in training and in mastering the theoretical knowledge. / 38

And then finally arrived the day of the next space experiment. Again this was a group flight of two spacecraft, but besides V. F. Bykovskiy, the first woman cosmonaut in the world, V. V. Tereshkova participated in it. "The flight of Tereshkova," said S. P. Korolev in his statement to the journalists, "this above all is one of the most striking demonstrations of the equality of Soviet women, their great courage. . . Secondly, the flight of women into space is evidence of the high level of our technology. This technology is manageable not only for an experienced pilot, but also for man not having flight experience. It is now clear that the problem of cosmonaut preparation is solved. . . "

The last remark of S. P. Korolev is particularly important since the complexity of the problems to be performed during space flights and the significant complication of space technology required in the Soviet program of manned flights, as well as in the American, participation in the flights of spacecraft of specialists in the area of space technology with great experience in design and test / 39 operations. At this same time began the development of the famous idea of K. E. Tsiolkovkiy about the creation of "ether settlements" of man -- long-term manned orbital stations. With the organization of these scientific laboratories in space, there arose all the more the problem of sending for work beyond the earth cosmonauts of "narrow" specialties -- physicians, biologists, engineers and physicists.

Thus, in speaking about the problem of cosmonaut preparation being solved after the flight of V. V. Tereshkova, S. P. Korolev had in mind above all the urgent necessity of launching scientist-specialists into space. And there again was the first crew and the first scientist cosmonauts to be first into space. In evaluating the flight of the Voskhod spacecraft, S. P. Korolev noted: "From now on, after the flight of Feoktistov, the road to space has been opened for scientists. . . " And later: "Anyone could fly off with pleasure, if age permits. . . "

The detachment of cosmonauts was soon reinforced, apart from K. P. Feoktistov and B. B. Yegorov, who had already been in space, with the future flight engineers and spacecraft test engineers, A. F. Yeliseyev, V. N. Volkov, V. N. Kubasov, V. I. Patsayev, N. N. Rukavishnikov, V. I. Sevast'yanov and other scientists. Even earlier, G. T. Beregovoy, G. T. Dobrovol'skiy, A. V. Filipchenko, V. A. Shatalov and others, who were more experienced (the problem of age was already not so important) as compared with the cosmonauts of the "Gagarin set", had entered the detachment. At this same time, the further organization of Star City continued -- the construction of new buildings, laboratories and playing fields.

March 1965 is marked by yet another outstanding event in astronautics -- the Soviet cosmonaut, A. A. Leonov was first to exit from the spacecraft into open space. "The flight of Yuriy Gagarin opened the epoch of space navigation," wrote S. P. Korolev in one of his last articles, "and the epoch of man working in free space began. . . when Aleksey Leonov took a step from the lock into open space and drifted freely in it."

As the participant of the first space walk himself recalls: "I was worried. . . / 40 about overcoming the psychological barrier. . . Even K. E. Tsiolkovskiy wrote about the psychological barrier which could arise for man first leaving the spacecraft and deciding to step into the abyss. This barrier is overcome, for example, by the parachutist first leaving an aircraft. We thought it would be about like that. We flew on aircraft and jumped with parachute". And the remarkable space experiment was actually successfully accomplished.

At the end of the flight of the Voskhod-2 spacecraft, from which A. A. Leonov had exited into open space, the manual landing control system was first used and completely skillfully accomplished by the craft commander, P. I. Belyayev. "I have also successfully taken my step on the path of man to the stars," recalls pilot cosmonaut, P. I. Belyayev. "Those operations have been performed for the first time, which will become an ordinary affair for the commanders of all future interplanetary spacecraft".

After the 15 years of space navigation begun by Yu. A. Gagarin, undoubtedly the most significant achievements of American space technology, as well as for all mankind, were the flight around the moon with injection into lunar orbit (Apollo-8) and the first landing of man on the moon (Apollo-11). In 1969, the

first American astronaut, F. Borman (the commander of Apollo-8) travelling in the Soviet Union said at a press conference held in his honor: "I am very happy to be here in Star City. I consider it an honor to visit the ground from which your remarkable countryman, Yuriy Gagarin took the step into space. The achievements of American and Soviet astronauts in space have now become achievements of peoples; they go beyond national boundaries. . . " G. T. Beregovoy, in the name of Star City, presented F. Borman a miniature model of the Vostok spacecraft. "From here, from this ground, man went into space in order to open the door for all mankind," said G. T. Beregovoy. "May this small model of the spacecraft remind you of the feat of the first to open space".

A year after his legendary flight to the moon, the commander of the Apollo-11 spacecraft, N. Armstrong visited the Soviet Union. At his press conference held / 41
in the Academy of Sciences of the USSR, in responding to a question about Soviet-American collaboration in space, the astronaut answered: "The collaboration of peoples in the problems of the conquest of space is very important and, of course, I would want to take part in a space flight together with my Soviet colleagues. I would be happy to meet them in space and to shake their hands."

Later, at the memorial room for Yu. A. Gagarin in Star City, N. Armstrong wrote in the Memorial book: "He called us all to space!"

Fifteen years have passed since the Soviet space program begun by Yu. A. Gagarin and S. P. Korolev has been sucessively and steadily carried out. Thanks to the successes achieved in Soviet astronautics, the idea of K. E. Tsiolkovskiy about "ether settlements" of man has begun to be accomplished. Because of the group flights of the new powerful Soyuz spacecraft, whose development was begun by S. P. Korolev, because of the first docking of the manned Soyuz spacecraft in orbit around the Earth, whole laboratories were launched one after the other -- the Salyut orbital space stations.

The flight of the Salyut station with the crew of G. T. Dobrovol'skiy, V. N. Volkov and V. I. Patsayev gave the first experience in the functioning of heavy spacecraft of the new type, permitted obtaining valuable data about the possibilities of long stay and work of man in space, demonstrated the wide range of possibilities of orbital stations -- from the investigation of the natural environment and resources of the Earth to astronomical research. The second crew

of the Salyut-4 orbital station, P. I. Klimuk and V. I. Sevast'yanov accomplished the longest flight in the history of Soviet astronautics.

In 1975, the two space powers -- the USSR and the USA -- accomplished a notable experiment in the ASTP program. It is significant that A. A. Leonov, the closed friend of Yu. A. Gagarin, became commander of the Soyuz-19 participating in this experiment. At his first press conference after the flight on Vostok, Yu. A. Gagarin declared: "We are always happy about the successes in the development of science in other countries, happy to welcome astronauts of other countries into space. We wish them great successes in the peaceful conquest of space and want to collaborate along with them in the peaceful utilization of space. . . " / 42

However, rather much time was needed before the dream of the first voyager of space became a reality. This became possible only when, as L. I. Brezhnev noted, "the relaxation of tensions, improvements in Soviet-American relations created the conditions for carrying out the first international space flight." / 43

More than a half century before, the great Russian scientist, the founder of theoretical astronautics, K. E. Tsiolkovskiy wrote such exciting and prophetic words: "The Earth is the cradle of reason. But it is impossible to live forever in a cradle." Today, in stepping over the threshold of the 15th anniversary of the first manned flight, we can see further -- man has already left his "cradle" and he will soon conquer the solar system. However, even this is only a step to the stars.

"The land of youth, the poet called our whole country, the homeland of astronautics," said Yu. A. Gagarin. "I am sure that on this remarkable ground the new, still accumulating forces of science about flights to the stars will gather a lavish harvest!"

FIRST VOYAGERS OF THE STELLAR OCEAN

. . . Space is the place of application of the work and talent of people of the most varied terrestrial specialties . . .

Yu. A. Gagarin

Yu. A. Gagarin after his flight on the Vostok spacecraft became the father of a new profession -- the profession of astronaut. The role and active participation of people of the new profession in the conquest of space grew more and more with each subsequent flight. In the 15 years since April 1961, 57 launches of spacecraft with astronauts on board have been accomplished in the USSR and the USA, and already 77 men have been in space. What then are the basic characteristics of the profession of these courageous people -- the first voyagers of the stellar ocean?

Before answering this question, let us consider another -- is man even necessary onboard a spacecraft, if some of his functions can be performed by automated mechanism and computer? Actually, the astronaut is in a certain sense only a valuable and useful part of the modern complex placed on the craft. In / 44
this complex -- "man - machine" -- the astronaut enters as a single system, is its important functional unit and supplements in his qualities and properties the other elements of this system.

However, man has a number of properties, which make him not only a valuable part of such a space research complex, but moreover extremely necessary. These properties include, for example, the amazing capability of the astronaut for adaptation, i.e. the capability of easily adjusting to very complex systems of the spacecraft and to control them as he would control an automobile, jet aircraft or a fast sailing vessel on the Earth. These properties also include the human memory. The memory of the astronaut sent into flight is by no means just a notebook where is written in the finest detail everything that he must know

and do to perform his assignment. When the astronaut encounters some problem, particularly "unprogrammed", he calls upon all his life experience, recalls analogous or similar situations and only on this basis finds the correct way out of the situation.

Finally, the astronaut has the sharply expressed capability for self-analysis and abstract thought. It is well known that man can commit errors. However, he has the capability not only of noting and correcting them, but he can also detect errors or anomolies in the operation of the complex system of which he is a part onboard the spacecraft. Man can show his mind and common sense -- qualities which are not possessed (and cannot be possessed) by the most perfect machines. This capability of man determines his important role in the investigation of space; this role will probably not decrease in the near future. And numerous examples from space operations verify this conclusion.

In May 1963, the American spacecraft Faith-7 (from the Mercury series) piloted by Air Force Major G. Cooper was launched into orbit around the Earth. The craft was in orbit with a perigee of 160 km and an apogee of 270 km, and the / 45 flight was proceeding normally when suddenly in the 19th orbit trouble was observed in the electrical system of the spacecraft cabin. This trouble could not be eliminated and as a result G. Cooper had to fire the retrorockets himself "manually". The flight ended safely and the capsule with the astronaut splashed down 7 km at most from the waiting aircraft carrier Kearsarge

A similar case occurred with the Soviet spacecraft Voskhod-2 in March 1965; before the end of the flight, the command to fire the retrorocket did not work (equipment of the automatic orientation system failed) and the craft commander, P. I. Velyayev had to complete a landing, again with the use of the manual control system.

In June of the same year during the flight of astronauts J. McDivitt and E. White on the Gemini-4 craft, the onboard computer failed in the 48th orbit, i.e. the automatic craft control had failed. And the most critical phase of the flight occurred at this time -- entry into the dense layers of the atmosphere. However, even here the astronauts quickly evaluated the situation, switched to manual control and returned safely to Earth.

Finally, a more dramatic situation arose during the flight of Gemini-8, launched in March 1966, when after a successful docking carried out by N. Armstrong and D. Scott, the craft unexpectedly lost control and began to turn like a helpless top. Only the presence of mind and the unsurpassed mastery enabled N. Armstrong to land the craft on the waters of the Pacific Ocean.

Thus, it is quite obvious in all these cases that it was the astronaut who saved the situation.

In answering a question about the role of automated and manned equipment in space research, Yu. A. Gagarin said: "The future of astronautics is difficult to imagine without manned equipment. It is inconceivable to master, to conquer space with single automated and lunar interplanetary stations. There is no doubt that much is being said and will be said about them, but, in my view, these stations are only the first line in the attack on space. Only man can secure victory, hold / 46
the conquered for himself".

Thus, the participation of the astronaut is decisive in the wide set of problems standing before mankind in the conquest and investigation of space. For example, there are now so many satellites in orbit around the Earth, whose equipment has suddenly failed (for example, failure of a transistor or some other element in the electronic units of the control systems), and because of this the planned program of investigation (perhaps very expensive) has been ruined. But it would be sufficient to launch an astrnaut into orbit, who in eliminating the trouble on the satellite could save this entire program. Of course, the cost of launching a spacecraft is still too high to resort to the help of an astronaut in such cases. However, such help will become completely ordinary with time.

But this is in the future, and for now the testing of spacecraft systems and equipment is almost the basic problem before the astrnauts. In order to somehow reduce the danger of flight for the astronauts, the creation of even the first spacecraft in the Soviet Union was based on the principle of the wide use of various automatic systems on board for the first launches, and only after some time in later launches were the functions of the automatic systems gradually transferred to man. The astronaut in flight then had the maximum freedom from the responsibilities of craft control, and he had sufficient time to perform the various scientific and technical experiments. However, there have been cases of

automatic device failure (as have already been discussed above), and then the astronaut was converted into a full tester, the "most dangerous of the dangerous" professions.

The development of the first spacecraft in the USA proceeded along a somewhat different path. Since the first astronauts were test pilots, a "control relief" system was used in the design of the spacecraft cabin, which is used for cruising flight in aircraft -- autopilots, whose gyroscopic part generates and delivers to the control system signals which provide for stabilization of the specified spacial orientation of the aircraft. / 47

Moreover, in the first American Mercury spacecraft, the astronaut could also control the craft with the help of a manual jet control system connected in parallel with the automatic system. He also had the possibility of "manually" (i.e. independently) firing the retrorocket and opening the drag parachute (although, of course, there was an onboard automatic system subject to commands from the Earth). In observing stars or the surface of the Earth through the porthole, the astronaut could also independently determine and correct yaw and drift of the craft, as is done on aircraft.

Thus, the first astronauts in the USA took a more active role in the control of the craft. However, the decrease in the role of automation in the first spacecraft of the USA undoubtedly increased the risk of operation of the astronauts under space flight conditions and, in addition to this, required enlisting more experienced test pilots. (While Yu. A. Gagarin accomplished his flight at 27 years of age and G. S. Titov at 26, J. Glenn, the first American astronaut to accomplish orbital flight, was 41 and M. Carpenter, who repeated the 4-orbit flight of J. Glenn, was 37.) As was already stated before, automatic devices were widely used in the USSR to ensure safety of the first cosmonauts, and thus the requirements on the professional qualities of the first cosmonauts were reduced (their experience as jet pilots was sufficient and it was not required that they be professional test pilots).

The basic problems of the techniques of manned space flight were solved after thorough finishing of the systems of the first spacecraft, and extensive knowledge in various areas of science, technology and, in particular, experience of a tester capable of monitoring the operation of all on board systems of the

spacecraft is now required from the present-day astronaut. As the same time, the astronaut also became a research scientist, capable of obtaining valuable information about the surrounding space, the atmosphere and surface of the Earth with the help of scientific equipment during the flight. Flight preparation now requires from the astronauts a significant amount of work on Earth: they spend much time / 48
in scientific research institutes, laboratories and observatories; they create along with scientists and engineers systematic programs for performing unique experiments in space; they participate in the production and ground tests of scientific equipment for spacecraft and orbital stations.

The development of long-term orbital stations has required enlisting not only test pilots but also specialists of other professions. In comparing the history of the development of aviation and astronautics, Yu. A. Gagarin wrote: "At first only pilots flew aircraft; everyone who flew above the Earth was called a pilot. The multi-position aircraft appeared -- and navigators, radio operators, flight engineers came into being. Finally, passengers appeared. It will be the same in astronautics. The first Soviet multi-position spacecraft Voskhod piloted by pilot astronaut Vladimir Komarov already had in its crew a acientist astronaut and a physician astronaut. There will be in time engineer astronauts, physicist astronauts, builder astronauts, welders, astronomers . . . "

Astronauts of various specialties -- flight engineers, test engineers, etc. -- participated widely in space flights after the creation of multi-position spacecraft in the USSR. In the American program of manned space flights, civilian pilots were enlisted along with the military pilots for these flights for the first time. However, the participation of scientists in manned flights was used significantly later -- with the implementation of the Apollo and Skylab programs. The first American civilian astronaut (pilot) was N. Armstrong, who accomplished his first flight on Gemini-8 in March 1966. Another civilian specialist, W. Cunningham participated in the first manned flight of the Apollo spacecraft (on Apollo-7 in October 1968). The civilian astronaut, Russell Schweickart participated in the flight of Apollo-9 in March 1969. Two civilian astronauts, F. Haise and J. Swigert were in the crew of Apollo-13. And finally, H. Schmitt, the only scientist to stay on the Moon, participated in the last expedition to the Moon.

The first 6 flights of the Apollo spacecraft, including two flights around / 49
the Moon and two landings on its surface, were successful. But the 7th manned

flight ended almost catastrophically and we were convinced once again of the risks related to the penetration of man into space.

The third lunar expedition consisteing of J. Lovell, J. Swigert and F. Haise left for the moon on April 11, 1970 on the Apollo-13 spacecraft for a landing in the region of the crater Fra Mauro. On April 14, 56 hrs after launch, when the craft was at a distance of 328,000 km from the Earth, an accident occurred -- the main battery of the spacecraft failed as the result of a short circuit and rupture of one of the oxygen tanks in the engine section. The extraordinarily stressful journey of the astronauts continued for 6 days, and for this time the courageous astronauts, in eliminating the trouble with incredible composure, and the ground personnel working with no less stress succeeded in coping with the apparently impossible problem. The rescue operation for the Apollo-13 crew, even more than the lunar landing itself, showed what man could achieve. In spite of the help of computers capable of calculating time and distance in a billionth of a second, the expedition was saved, in the final analysis, not by machine, but by people -- both those in space and those working on the Earth. About ten countries, including the Soviet Union, expressed their readiness to assign their ships and aircraft for carrying out the rescue operation and thereby emphasized once again the necessity of wide international collaboration in the peaceful conquest of space.

The problem of the participation of specialists of the various scientists was finally decided with the construction of large orbital space stations with interchangeable crews. The creation of long-term inhabited base stations of block design is the final goal of manned flights in Earth orbit. The first stage of this path must be the development of a station consisting of a single block, which can later form a part of the base station as one of the blocks. (This is where the profession of assembler astronaut takes a new direction -- space city construction.) The tendency for increasing the number of experiments is clearly traced in the / 50
flights of the Soviet Salyut stations and the American Skylab; the range of problems to be solved in space is becoming ever broader; their complexity is increasing. The scientific experiments have been divided into three groups: scientific, technical and biomedical. Investigations related to these groups are being carried out at present in all flights.

In the course of a year, three parties of astronauts were taken to the American

Skylab station with an interval of several months. The first party spent 28 days on the station, the main consideration being given to the repair of the station, which had been damaged during injection into orbit. The second party of astronauts spent 59 days on the station, which was the logical stage in the successive increase in duration on the station and verification of the capability of people and equipment to function effectively in space for a longer period. This was the first experience in the repeated use by astronauts of an orbital object, which had been in orbit without servicing for several months.

The third party spent 84 days on the station, and with the evacuation of the third party the operation of the station concluded. Besides the observations with the help of astronomical instruments, the main consideration was given to biomedical experiments, in particular physiological and psychophysiological investigations to evaluate the capability of man to live and work under conditions of long space flight.

A somewhat analogous program of investigations was performed in 1975, when two parties of cosmonauts in succession landed on the Soviet station Salyut-4. The second crew consisting of P. I. Klimuk and V. I. Sevast'yanov worked about 63 days on the station -- the longest flight in Soviet astronautics.

Astronauts of the most varied specialties have worked on board both the American and Soviet orbital stations. For example, a member of the second crew of the Skylab orbital station, O. Garriott is an electronics specialist and has taught the theory of electromagnetism and the physics of the ionosphere at Stanford University; D. Kerwin -- a member of the first crew of Skylab -- is a specialist / 51 in aviation medicine; E. Gibson -- a member of the third crew of Skylab -- is a physicist. G. Grechko and V. Sevast'yanov -- members of the crew of the Salyut orbital station -- are candidates of technical science, research engineers.

There is no doubt that the present-day astronaut must have impeccable health. Both the preparation on Earth and the flight itself require the maximum exertion of all the physical and moral strengths. Without comprehensive physical preparation, it is impossible to properly assimilate space technology, it is impossible to assist in the further development of astronautics related to the constant and long operation of man in space, to the solution of problems of an applied nature in the interests of vaious branches of the national economy.

What the essence of this first space traveller would be was guessed at many years before the first flight of man around the Earth. Many foreign visionaries supposed that he would need bones of steel and mighty muscles to withstand the acceleration, the lungs of a glass blower, the strong heart and agility of an acrobat and also the subconscious desire for death, if not a schizophrenic striving for solitude.

An image of the astronaut, closer to reality, was predicted by the representatives of an unusual branch of medicine -- bioastronautics. The model steller navigator was pictured by them as a young man of high intellectual capacity, but, so to speak, normal "to an unnormal degree". On Earth, he could be a diver, a circus gymnast, a champion in pole vaulting or an acrobat. His lungs and heart must be healthy, but not necessarily exceptionally developed: the necessary air pressure will be maintained in the cabin. Excessively strong muscles could even be a disadvantage since the astronaut will have nowhere to exercise them: under the weightless conditions of space the force of a year-old baby is sufficient. A well-formed body and a short strong neck will aid him to endure the overload during ascent. Most important, from the point of view of these specialists, is that the functioning of the digestive system of the astronaut not be disrupted by weightlessness: the astronaut must not suffer from "sea sickness".

How could the doctors, even those working in the area of aviation and space / 52
medicine, know what qualities the ideal interplantetary traveller must have? How could they study the conditions, which do not exist on Earth and which in some cases are impossible even to create artificially?

Until recently, weightlessness was considered a very serious danger threatening man in space flight. However, it has now been established that the astronaut adapts to this state. It was expected before the first manned space flights that the astronaut under weightless conditions would be set upon by the most diverse disorders (softening of the bones and loss of weight, decrease in muscle tone, "sea sickness", etc.). However, Soviet and American astronauts during flights lasting more than two months have received in one form or another only a few of these disorders.

Particularly great apprehensions were raised by the supposition that the astronaut under weightless conditions would lose the capability for orientation,

since his vestibular apparatus would have to function in the absence of a gravitational field. The vestibular apparatus is a complex biological system. It consists of three semi-circular canals and the otolithic organs, which are often compared to the inertial stabilization system of a spacecraft or, at least, with its stabilized platform. The three semi-circular canals positioned in mutually perpendicular planes are also angular acceleration receptors.

Only a few disorders of the capability for orientation of the astronauts were observed in the first flights, and only G. S. Titov (Vostok-2) was predisposed to "seasickness". Cosmonauts B. B. Yegorov and K. P. Feoktistov (Voskhod) felt that they were upside down for a large part of the flight. They also experienced a little dizziness both with rapid as well as with slow turns of the head. In addition to this, B. B. Yegorov had a loss of appetite and an unpleasant feeling in his stomach, which reached a maximum in the seventh hour of the flight. However, not one of the cosmonauts lost the ability to work. At the same time, the commander of the Voskhod craft, V. M. Komarov did not experience any unpleasant or ill effects of weightlessness. Evidently, training plays a large role in the adaptation of the cosmonaut to conditions of weightlessness: Komarov had several / 53
years of special training behind him, whereas Yegorov and Feoktistov had trained only several months. It is very important that the capability of orientation not be disrupted for astronauts, who go out into open space.

A totally new phenomenon of the effect of weightlessness on the human organism was encountered with the return to Earth of the crew of Soyuz-9. During the flight, the cosmonauts performed a general program of biomedical investigations on the study of the effect of a long stay in orbit. Problems of the adaptation of the human organism were studied, the effect of weightlessness and the decreased muscular activity on the metabolic processes, the cardio-vascular system, the skeletal apparatus and the nature of the blood circulation. Interesting results were obtained with the investigation of the dynamic functions of man as an element of the control system. A number of biomedical and psychophysiological methods were used to evaluate the capability of the crew at various stages of the flight. "We came through the flight well," A. G. Nikolayev said later at the press conference, "and, speaking frankly, we did not expect that certain difficulties in getting accustomed again to conditions of life on the Earth or, as the physicians say, readaptation would appear after landing".

However, it was the extensive biomedical experiments performed during flight which permitted Soviet physicians at the press conference after the return of Soyuz-9 to declare that the Soviet Union has sufficient grounds to pass onto flights of increasing duration, keeping in mind the reliable and comprehensive biomedical provision for the health of man in the conquest of space with consideration of overcoming the effect of readaptation. The flights of the Soyuz-11 and Soyuz-18 spacecraft can serve as examples of the increasing length of time under space conditions. The results of the flight and work of the cosmonauts P. I. Klimuk and V. I. Sevast'yanov during 63 days on the Salyut-4 orbital station are being thoroughly investigated at present by physicians and other specialists to prepare for future, even longer space expeditions.

O. G. Gazenko, the well-known Soviet scientist in space medicine, reached / 54
the conclusion after the 18-day flight of Soyuz-9 that the changes in the physiological functions of the crew were basically normalized within 10 days after returning to Earth. Having available considerable material of biomedical investigations during the flight of the American crews of the Skylab orbital station, scientists of the USA reached the conclusion that the human organism is capable of adapting completely to weightless conditions after 30 - 40 days in space, and the subsequent capability of the astronaut is completely preserved, in the opinion of these specialists, for a rather large interval of time. However, as these same specialists note, the decrease in the amount of calcium in the human organism in the state of weightlessness for 2 - 3 years remains a very important problem for future expeditions to Mars. The American scientists assume that great difficulties will arise in sending an expedition to Mars with the return of the astronauts to the Earth. The members of this expedition, after remaining completely healthy and capable of working under weightless conditions, will risk returning to Earth with extremely softened skeletons because of the considerable decrease in calcium.

Of course, this problem is temporary. Now that man has landed on the Moon, which can be called the first foothold in space, he will undoubtedly, as A. M. Gor'kiy said, "climb on to Mars" and in the end expand the sphere of his activity to the other planets of the solar system.

SPACE TO THE PEOPLE

Space promises us mountains of bread
and a world of power.
K. E. Tsiolkovskiy

According to the expression of the noted flyer and writer Antoine de St. Exupéry, "the airplane is a machine, but what an instrument of knowledge!" This refers to an even greater degree to space technology, and how every effective instrument of knowledge serves to help man solve both purely scientific and applied problems.

The manned space programs contribute significantly to the development of / 55
science. They are intimately related with the scientific and technical progress of the national economy, and in turn affect its development. Space research has a more direct importance for deepening the understanding of the space around the Earth, which is important for creating and operating space facilities and for planning operations in the research and utilization of space for peaceful purposes.

One of the most valuable results of the accomplishments of the space programs is that they provide the criterion for evaluating the possibility of using space in the most advantageous manner. This can also be related to the advantages of space research, since progress in space technology creates the possibility of a wide selection of promising programs, each of which, in the estimation of the specialists, can give economic gain measured in billions of rubles.

The entrance into space, free from the bonds of the gravity of the Earth, permits carrying out investigations of the solar system and the universe, which are impossible under terrestrial conditions, to study the Earth-Sun relation, to accumulate qualitatively new and simply statistical data about the Earth and the space surrounding it. The importance of space research for science consists mainly of the fact that it makes it possible in a number of cases to solve problems at the forefront of science with greater effectiveness than other research, while

in several cases the other methods are completely unacceptable.

"Space research," Academician B. N. Petrov notes, "has acquired truly global significance in our time. In a comparatively short time, the satellites, spacecraft and automatic interplanetary stations have given unique scientific material, which would have taken long years of persistent work to acquire by previous methods, and much of it would have been completely inconceivable".

Actually, the space around the Earth is a very valuable laboratory, where experiments can be carried out without many limitations in the area of plasma / 56
physics, high energy particles and magnetic fields; fundamental experiments are performed in studying the effects predicted by the theory of relativity and also in studying the nature of gravitation. At the present time, the physics of the Earth, space around the Earth and other objects of the solar system have advanced significantly thanks to space research. This is particularly important since investigations, in particular, of the space around the Earth has great practical value for the more reasonable study and use of Earth resources and also for other applied purposes.

In the Soviet Union, a gradual program of study and use of space for peaceful purposes is being systematically accomplished. The Salyut orbital space station has been assigned a tremendous role in this program. After the successful completion of the group flight of the Soyuz-6, -7 and -8, L. I. Brezhnev noted: "Soviet science considers the creation of the orbital stations with interchangeable crews as the main path of man to space. They can become "cosmodromes in space", launch areas for flights to the other planets. Large scientific laboratories have come into being to investigate space technology and biology, medicine and geophysics, astronomy and astrophysics. There have now appeared the real possibilities of accomplishing the predictions of our great countryman, Konstantin Eduardovich Tsiolkovskiy that man would create stations and laboratories in space."

Work in the area of space technology has been successfully carried out for more than 10 years by the co-workers of the Institute of Electric Welding of the AN UkrSSR. With the help of their unique Vulkan installation, V. N. Kubasov during his flight on Soyuz-6 first carried out a series of experiments in welding and cutting metals directly under space conditions. During the combined flight of the Soviet and American craft in the EPAS program, a "general-purpose furnace"

experiment was also performed, during which were studied hardening, crystal growth and other processes of phase transformations of materials with heating of various samples in the electric furnace under weightless conditions.

As the state of this problem at present is outlined by Academician B. Ye Paton: "The experience of the last flights has shown that space equipment in / 57
weightlessness can be subject to rather serious repair directly in space. Operations related to welding, cutting, soldering and glueing of parts can also be required in the assembly of large orbital stations built from blocks sent individually into orbit. This requires the creation of equipment, technology and devices simplifying the operations in space and providing for their complete safety. . . "

It should be noted that the use of space facilities (both manned as well as unmanned) also has great promise in the national economy. In the main directions of development of the national economy for 1976 - 1980 taken by the XXV Congress of the Communist Party of the Soviet Union, it was proposed to "expand research in the application of space facilities for studying the natural resources of the Earth, in meteorology, oceanology, navigation, communications and for other requirements of the national economy".

However, this wide use of space facilities will undoubtedly cause a rapid development of space technology itself. The typification of space objects and the unification of their functional units, the use of reusable space transport systems, the creation of long-functioning multi-purpose space complexes performing various research and technological problems (from the development of production in space to unique geophysical laboratories) -- all of this leads to the formation of a new branch of the national economy.

Numerous biological experiments have been carried out in space under conditions of weightlessness and disruption of the terrestrial periodicity, which have permitted successfully revealing the role of time and the force of gravity in life processes. Such experiments have been carried out and are now being carried out with the help of automatic satellites, but performing such experiments on manned orbital stations has tremendous value. In particular, during the flight of the Soviet Salyut station, qualitatively new experiments were performed in observing the maturation of organisms and the development of their functions from their

conception to the mature state. Amphibian eggs, plant seeds and insects were used for these experiments. A large program of biomedical experiments in the investigation of blood circulation of the brain in the quiet state and after measured physical load was performed by the cosmonauts with the help of the Levkoy apparatus during the flight of Soyuz-13. / 58

During the following flights of the Soviet Salyut orbital space stations and the American Skylab, biomedical experiments were also assigned a large place in the programs of research with the help of these stations. In particular, along with the first crew of the American Skylab station, six mice in a cage and gnats in a glass jar went into space in order to help reveal whether the absence of the earth's gravitation affects the natural physiological rhythms.

The specialists of many, completely terrestrial services have evaluated the practical and applied use of space flights in full measure. "Space research studying the Earth from space has opened completely new prospects," emphasizes Academician B. N. Petrov. "Measurements in the various regions of the elctromagnetic spectrum -- from the ultraviolet to the infrared -- and also in the region of submillimeter and decimeter radio waves permit receiving valuable information about the radiation balance of our planet, the cloud, snow and ice cover of the Earth and oceans, the geomorphological characteristics, data about the nature and state of vegetation and much other information important for navigation, meteorology, geology, agriculture, studies of the ocean and Earth resources in general."

Meteorological investigations carried out on board spacecraft provide reliability of long-term weather forecasts and give operational information about the generation and movement of cyclones, tsunami and dust storms. For example, during the flight of Soyuz-9, cosmonauts A. G. Nikolayev and V. I. Sevast'yanov observed and photographed various atmospheric phenomena in order to use the obtained data in operational and long-term prediction of weather conditions. The cosmonauts repeatedly reported about thunderstorm phenomena and cyclones. Information about forest fires, dust storms and storms at sea was sent to Earth from the spacecraft. / 59

It is not difficult to imagine how great the role of space facilities is for monitoring the environment and studying the natural resources of our planet. The quantity and state of the vegetation covering the Earth are clearly seen in photographs from space taken in various spectral regions; the nature of the flora, the

moisture content and salinity of soils, the migration of biological predators are distinguished.

The latter is particularly important for agriculture. The devastated routes of agricultural predators, the destructive erosion of soil and, finally, the clear rectangular fields of various crops are actually seen from space. The view from space permits evaluating the activity of land reclamation systems and hydrotechnical construction and observing underground reserves of fresh water in arid and semi-desert regions.

For astronauts in spacecraft near the Earth, there are tremendous possibilities for investigating the closed and open reservoirs of the Earth and, in particular, the biological resources of the Pacific Ocean. For example, for the astronauts on board the American Skylab station, several days at most were required to compile an inventory of the water resources of the USA. Ten years had been required for this before, and when the work was completed, it was found that the obtained data were already obsolete.

Photographs from space contain much geological information. Their analysis has already become an independent method for studying the structure of the Earth's crust. The photographs reflect those features of its structure which are a result of the largest-scale global causes. Individual local details, in merging in photographs into parts of large elements, give an integral image of the relief of vast regions of the planet. It was also found that the structure of deep strata of the Earth's crust could be "seen" through loose deposits.

Observation and photography of individual, typical (from the geological point of view) regions of the Earth surface were performed by the cosmonauts during the flight of Soyuz-9. In particular, photographs were taken in the regions of the European part of the USSR, Kazakhstan and Western Siberia. Photographs were taken from geological survey aircraft simultaneously with the space experiment. Guided by the data of space investigations, in particular by the results obtained by the crew of Soyuz-9, geologists concluded that the mobile zone of crumpling and fractures of the Ural fold system extends far to the south and, judging from everything, intersects the desert of Central Asia and reaches to the Persian Gulf. / 60

In combination with information obtained by ordinary geological methods, space

data permit a more accurage and complete evaluation of the geography and reserves of mining regions, oil and gas provinces and coal basins and the detection of new, promising deposits of useful minerals. Space facilities can undoubtedly help prevent the depletion or even disappearance of natural resources due to irrational exploitation. Investigation of the Earth from space will also assist the search for new useful minerals, as are needed in our technical age.

Space research permits solving the problem of the global cartography of the surface of our planet. Space photography and cinematography, television monitoring and, in the future, holographic photography of the Earth will permit keeping constant track of its "face", which changes rather rapidly under the effect of the forces of nature as well as because of the economic activity of man. Similar experiments in geodesy and cartography have already been carried out on many spacecraft. American astronauts, for example, have already compiled a rough map of the natural resources of the USA.

Space facilities and, in particular, manned flights are a large service for transportation and ship and aircraft navigation. The flow in open waters are studied for these purposes and new routes are plotted.

The offspring of scientific and technical progress -- astronautics -- is at present "repaying the debt" to the traditional areas of technology. In particular, by taking solar plants beyond the atmosphere with wireless transmission of energy with the help of laser systems, mankind in the future will obtain a qualitatively / 61
new power base. There will also be nuclear power stations in orbit around the Earth in the not too distant future.

The investigation of space has basically an international character. No single country, however big it is, can accomplish alone a comprehensive program of space research. Geographical boundaries dictated by the small size of the Earth and the use of satellites far removed beyond the requirements of a single country give rise to the necessity of concluding international agreements and establishing close ties between the scientists and engineers of all countries. To carry out their own national programs, it was necessary for the USA and the USSR to conclude agreements with other countries in both hemispheres. Space research, whether it touches problems of communications, meterology or air navigation, requires the collaboration of all countries.

There is no doubt that the combined efforts of various countries will be needed for the further conquest of space -- especially since mankind is interested in the comprehensive information about his planet. This is also indicated by the large appropriations for space programs and for the construction of grandiose space and ground complexes (including launch and landing complexes at any point of the planet). It is necessary that there be broad international collaboration, the combination of national space programs into planet-wide programs, national participation in fabricating individual unified blocks (modules) of large space systems. This is the future of mankind entering into space. A token of that is the successful accomplishment of the first international experiment with the participation of manned craft of the USSR and the USA (ASTP).

In 1978, the United States plans to begin a new broad program of space flights -- with the use of spacecraft of a new type -- the multiple-use flying vehicle. The approaching era of the shuttle craft of this type has already captured the imagination of specialists. The preliminary plans for using the shuttle craft provide for carrying out more than 700 launches in the period from 1979 to 1990, i.e. more than one per week.

The creation of shuttle craft opens completely new prospects in space. Since / 62
they are designed for repeated use and will return to Earth like commercial aircraft, this will sharply reduce the cost of operations in space. Along with solving other problems, the shuttle craft will be used for carrying the satellites into orbit, which sharply reduces the expenses in performing this operation, for repairing automatic space stations and returning old satellites to Earth after the loss of their functional usefulness.

The space transport is an important key to the accomplishment of the plans of the American manned flight program. This craft is designed so that it can be used like an aircraft, which significantly reduces the expenses in delivering artificial satellites and people into orbit and returning them back to Earth. It will take off like a rocket and land like a jet liner. Such a craft can be used up to 100 times. "Space tugs" will transfer payloads from orbits near the Earth to higher orbits.

Mankind of the mid-20th century, having solved the problem of sending man into space and providing for the solution of problems of the future of our planet with

the help of space facilities, must solve a distant and even more important problem. Mankind cannot tie his future to our native planet alone. The brilliant dreamer of Kaluga wrote graphically about this. Any intelligent civilization would not remain forever on the small scale of a planet located in the system of a cooling star. Thus, human society, in developing, will naturally turn beyond the limits of the Earth -- in view of its limited surface (especially dry land) and the increase in the population of the planet.

Mankind is faced with going beyond the limits of the solar system and setting out to search for planets with conditions suitable for existence or creating artificial settlements near other stars.

Of course, this is a problem of the distant future, other generations of Earth men. Mankind of the second half of the 20th century, in going into space, must leave his descendants a centuries-long, global plan for the development of space facilities, which would take our civilization from the solar system to other worlds, to other planetary systems suitable for life. / 63

At all times, qualitative changes in the life of mankind were prepared by a fundamentally new approach to the understanding of the world; for this we are indebted to the genius of Copernicus, Darwin, Einstein, Tsiolkovskiy. K. E. Tsiolkovskiy said: "In order to assume a new method of seeing, man must be spiritually prepared, have fearlessness and unchained intellect. Then he is ready to encounter the future for the continuous and eternal process of search and discovery. His reward is the boundlessness of space, the comprehension of the secrets of the universe".